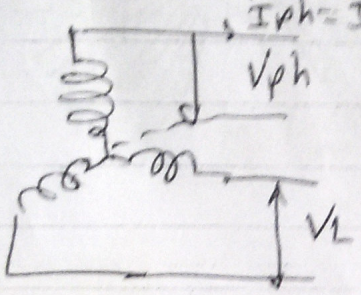
* Synchronous Machines **

Construction

a) - stator [Armature]

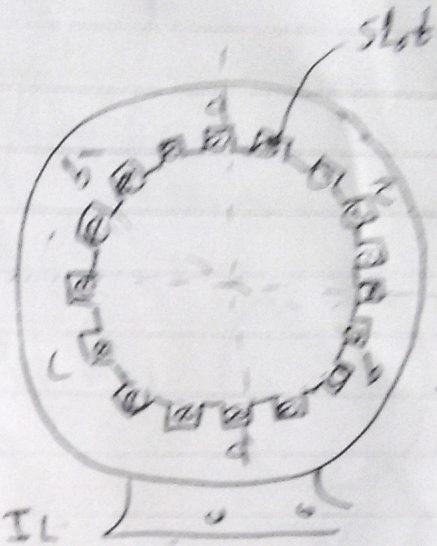
the same of 3-Φ I.M



star connection

$V_{ph} = \frac{V_L}{\sqrt{3}}$

$I_{ph} = I_L$

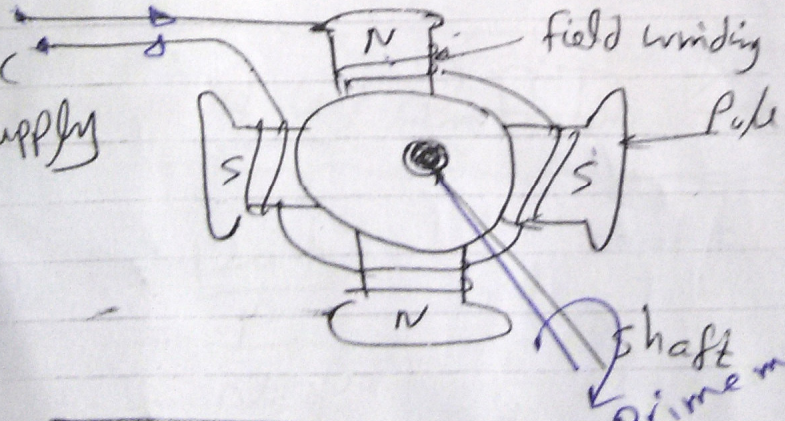


$I_{ph} = \frac{I_L}{\sqrt{3}}$

delta connection

b). rotor [field winding]

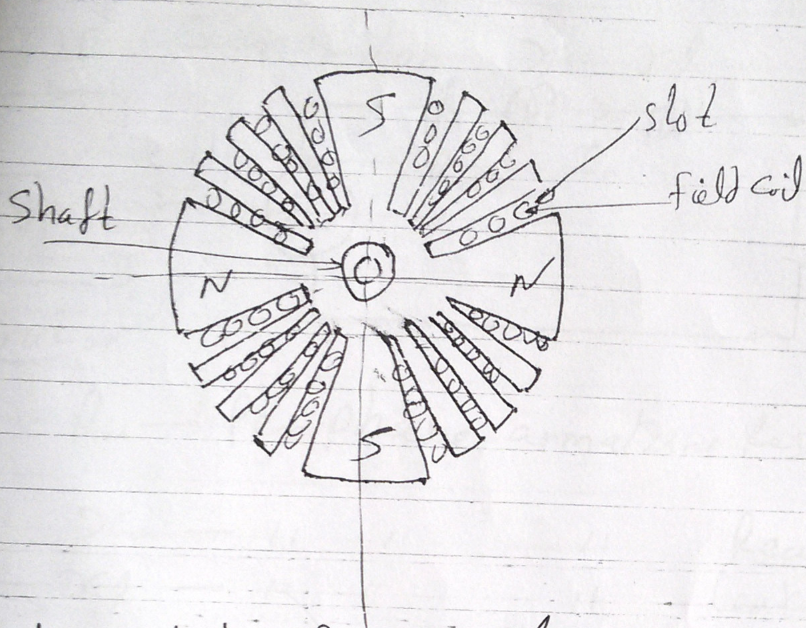
1- Salient Pole rotor



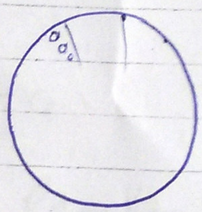
- * air gap is non uniform
- * Mechanically weak
- * Used for Low speed
- * Used for water turbine engines

P 7/4 No. of Pols

2- Cylindrical rotor



- air gap is uniform
- Mechanically robust
- used for high speed



Working Principle

فكرة العمل

بنغذي الـ rotor بـ DC ودورانه rotor بـ Ns

فإن الفيض الناتج من rotor يقطع ملفات Armature

فيتولد الـ e.m.f

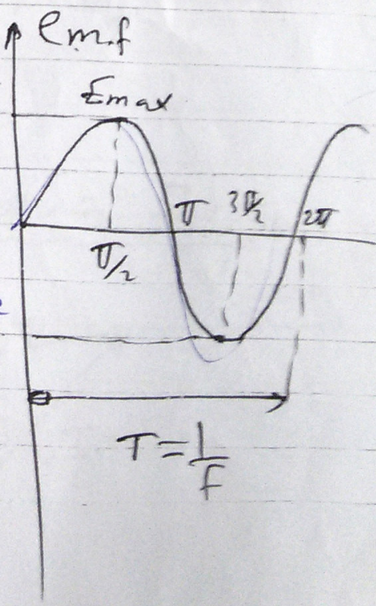
$$emf = N_{ph}\frac{d\phi}{dt}$$

$$E_{ph} = 4.44\,\phi_m f\,T_{ph}\,K_w$$

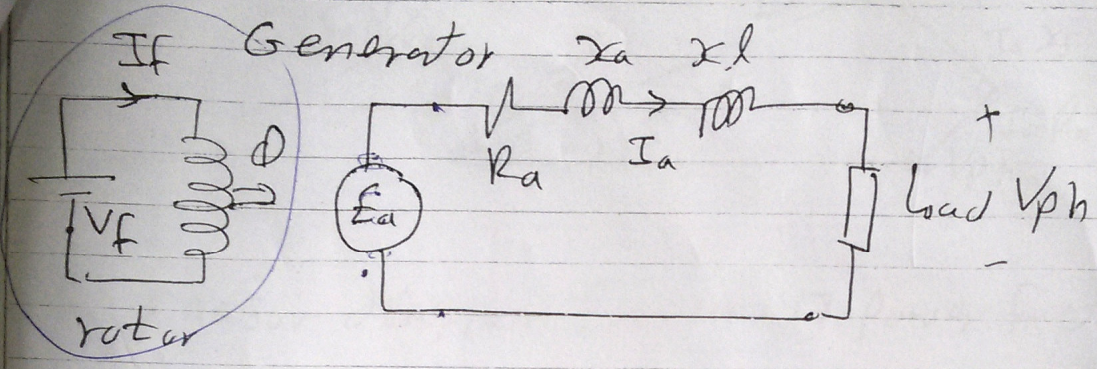
T_{ph} → no. of turns per phase

$$N_s = \frac{120f}{P}$$

$$f = \frac{N_s P}{120}$$



The per-phase equivalent circuit of synchronous

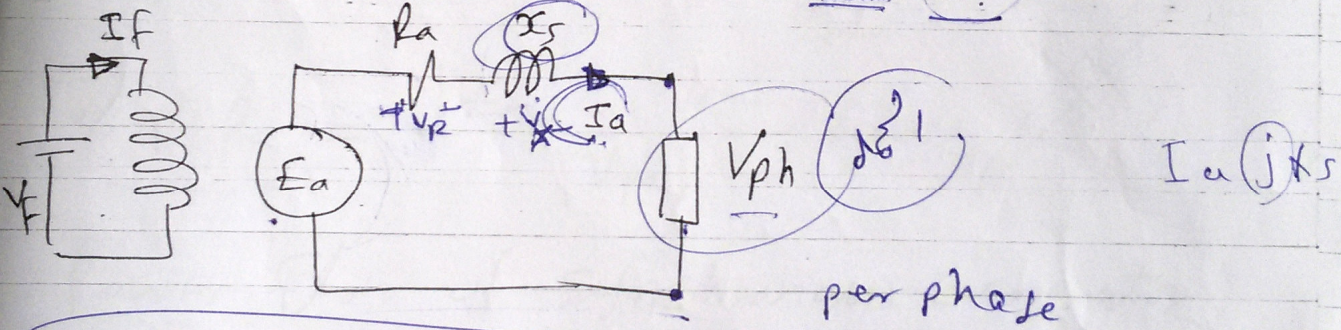


R_a → Per phase armature Resistance

x_a — " " " Reaction Reactance

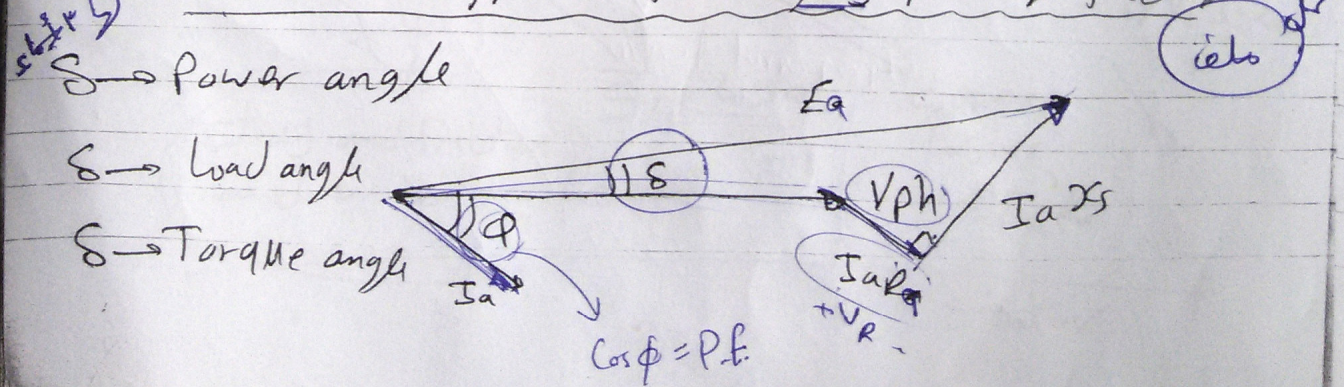
x_l — " " " Leakage Reactance

x_s → synchronous Reactance = $x_a + x_l$

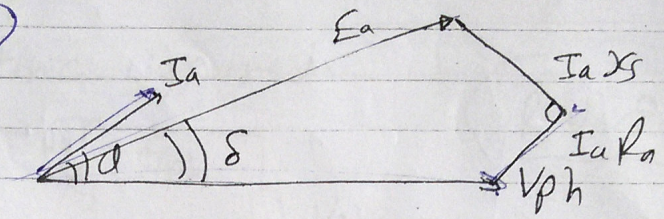


$$E_a = V_{ph} + I_a(R_a + jx_s)$$

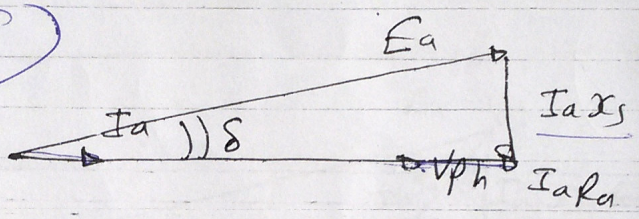
Phasor diagram for lag Power factor



Phasor diagram for lead power factor



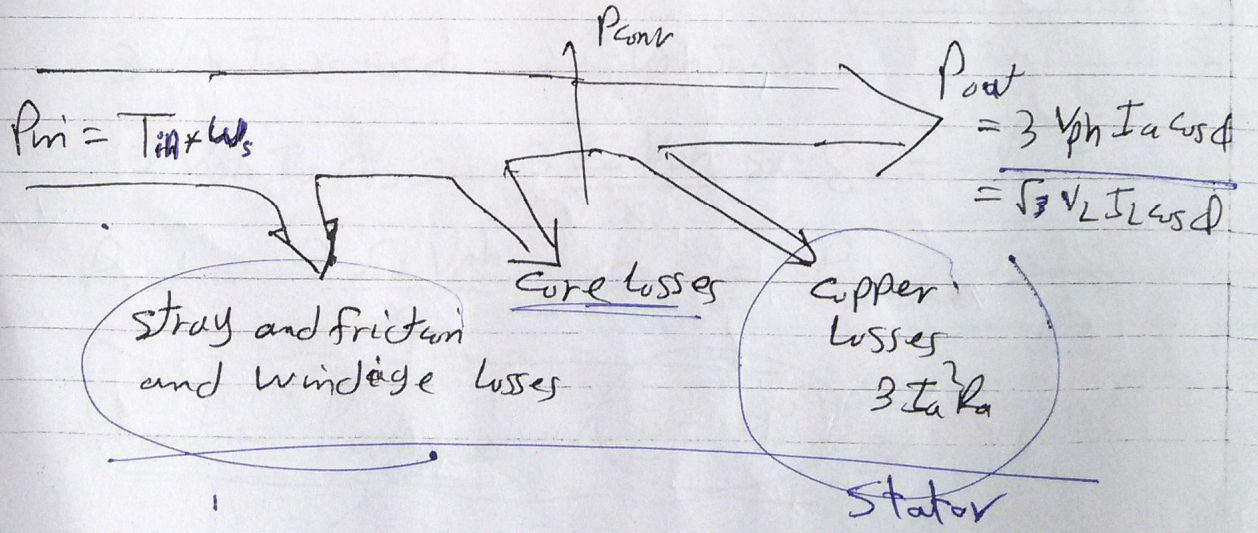
Phasor diagram for unity power factor



$$\%\ \text{Voltage Regulation} = \frac{V_{nL} - V_{fL}}{V_{fL}} \times 100$$

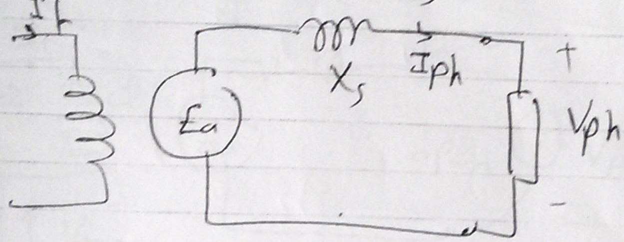
$$\%\ V.R = \frac{|E_a| - |V_{ph}|}{|V_{ph}|} \times 100$$

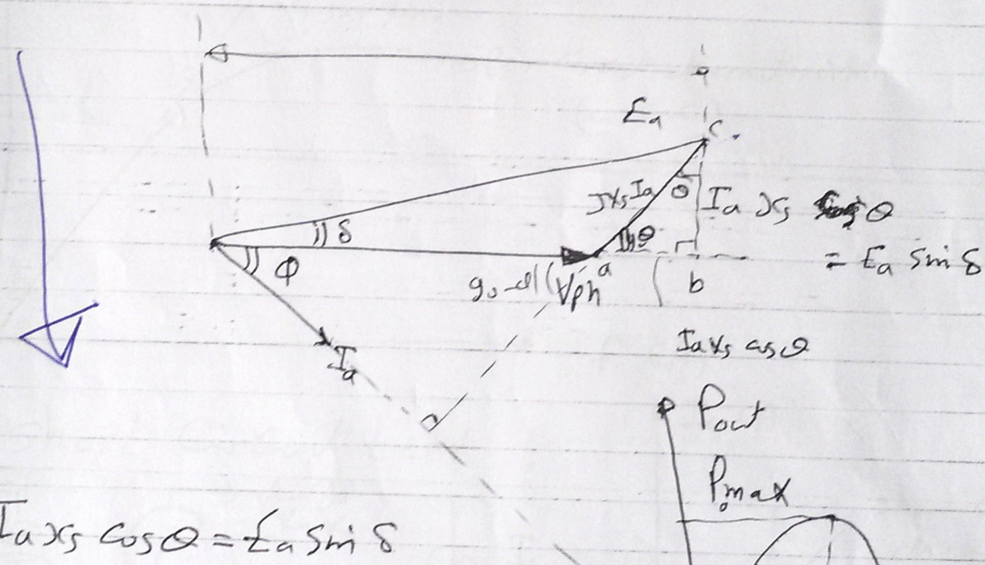
Power flow of synchronous Generator

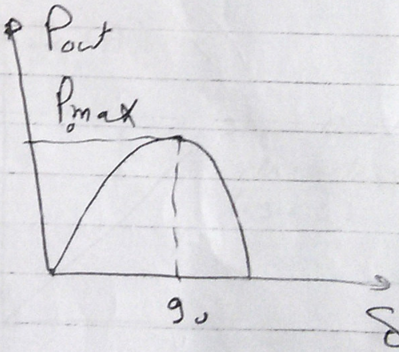


Simplified-phasor diagram with armature Resistance ignored.

(R_a [illegible])







$I_a x_s \cos\Phi = E_a \sin\delta$

بالضرب في $3 V_{ph}$

$3 V_{ph} I_a x_s \cos\Phi = 3 E_a V_{ph} \sin\delta$

$3 V_{ph} I_a \cos\Phi = \frac{3 E_a V_{ph}}{x_s} \sin\delta = P_{out}$

$P_{out} = \frac{3 E_a V_{ph}}{x_s} \sin\delta = P_{outmax} \sin\delta$

$P_{out} = P_{outmax}$ at $\delta = 90^\circ$

The Conditions Required for Paralleling

1- The rms line Voltages of the two generator must be equal

2- The two Generators must have the same phase sequence.

3- The phase angles of the two aphases must be equal

4- The frequency of the new generator, must be slightly higher than the frequency of the running system.

Starting synchronous Motors

هام للامتحان

المحرك التزامني غير قادر على بدء الحركة ولذلك نستخدم احدى الطرق الآتية للبدء

1- Motor Starting by Reducing Electrical frequency

2- Motor Starting with an External Prime Mover

3- Motor Starting by using damper winding

تجعله يعمل لحظة البدء

Induction Motor